Using Fishing Vessels to Collect Acoustic Data for Scientific Purposes:

Preliminary Results from Midwater Trawlers in the Eastern Bering Sea Walleye Pollock Fishery

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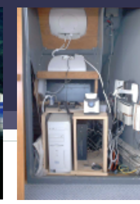

Introduction

Recent technological advances allow placement of scientific-quality echosounders on commercial fishing vessels and recording of the acoustic backscatter from these echosounders for subsequent analysis. Potential applications of this new data source are now being explored and include conducting informal surveys for real-time management of fisheries on spawning stocks, investigating the foraging behavior of fishing fleets, and studying spatial and temporal patterns of fish and zooplankton distribution. Here we report on a project to log acoustic backscatter data on midwater trawlers fishing for walleye pollock in the eastern Bering Sea, with the objective of evaluating fishing impacts on endangered Steller sea lions. Since our interest is in fine-scale spatial and temporal changes in abundance (i.e., tens of kilometers and weeks), work to date has focused on evaluating the spatial coverage of the data, and examining the general characteristics of cruise tracks and uncalibrated backscatter (UBS) data.

Methods

Our objective was to develop a logging system that would 1) require minimal attention, 2) could log raw acoustic data for entire fishing trips, 3) would be fully spatially and temporally referenced, and 4) would not interfere with the primary use of the echosounder as a fish-finding tool. Simrad 38 kHz ES60 echosounders on three factory trawlers were linked to 20 GB Iomega Peerless removable hard drives through a USB port. The ES60 was also set up to receive GPS fixes through a RS232 port. The ES60 was configured to store 100 MB raw data files. A simple "copy and delete" batch file was installed on the echosounder to transfer raw files to the data storage drive. Vessel operators only needed to change the data storage drives when prompted to do so by a interactive window appearing on the ES60 monitor.

Preliminary processing was done using the SonarData software package Echoview. Undifferentiated acoustic backscatter was integrated from 20 m below the transducer to 1 m above the bottom as detected by the bottom tracking algorithm in Echoview. Pollock are the dominant sound scatterers at 38 kHz in the southeast Bering Sea in winter. A scientific acoustic survey in winter 2002 in the same area attributed 99.5% of the total water column s_A to pollock. We make a distinction between uncalibrated backscatter (UBS) recorded on a fishing vessel from s_A obtained from a calibrated scientific echosounder. We have provisionally assumed that UBS is proportional to s_A, but recognize that additional work is needed to evaluate this assumption.

Factory trawlers in the eastern Bering Sea pollock fishery routinely carry observers. Sampling and record keeping by these observers provides detailed information on catches, including the set and retrieval time of each tow, total catch weight and species composition, and the length composition of the dominant species in the catch.

Results

For the most part, the data logging system worked as intended. On one vessel, the ES60 echosounder failed, precluding collection of acoustic data for the remainder of the season. On another vessel, there were problems with the echosounder configuration that caused the system to malfunction. For a single 38 kHz split beam transducer, the data drives provided approximately two weeks of storage capacity. A fundamental difficulty is the sheer volume of data collected (over 140 GB of acoustic data were logged by the three vessels during the winter season). Reprocessing the raw data on land by eliminating the split beam power and angle data and averaging low return samples achieved a 86% data reduction for a vessel with a single split-beam transducer.

Cruise tracks were confined mostly to the area of greatest fishery removals (Fig. 1), and there is substantial overlap between the cruise tracks by different vessels. Cruise tracks by individual vessels are complex and show considerable fine-scale structure, including multiple crossings that could potentially allow evaluation of changes in pollock distribution over time (Figs. 2 & 3). In comparison, the winter 2002 echo-integration survey by the NOAA research vessel R/V Miller Freeman made a single pass over the fishing grounds. Regularly spaced transects during the scientific survey enable straightforward inferences to population abundance, but the overall density of coverage is low compared to fishing vessels (Fig. 4).

The distribution of fishing vessel speed shows two modes, a mode at 4 knots (typical trawling speed) and another mode at 10-15 knots (typical cruising speed) (Fig. 5). One unexpected result is that vessels tend to run at 4 knots while on the fishing grounds even when not trawling. Apparently fishing vessels only run at cruising speed when traveling longer distances, e.g., when transiting to and from port.

We did not find a strong relationship between summed UBS while trawling and the total catch of a tow (Fig. 6). Fishermen are firmly convinced that there is relationship between fish detected by their vertical echosounders and the fish that enter the net while trawling. However they recognize the influence of other factors, such as the depth distribution of the fish, oceanographic currents, and fish avoidance of the vessel and the net. Further, the recorded set and retrieval times in the observer database may be inaccurate.

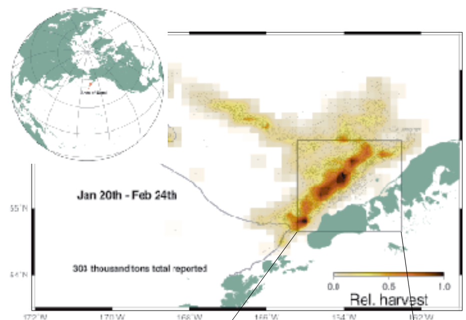

Fig 1. Spatial pattern of cumulative walleye pollock catch in the eastern Bering Sea during 20 Jan-24 Feb, 2002. Points indicate haul retrieval positions.

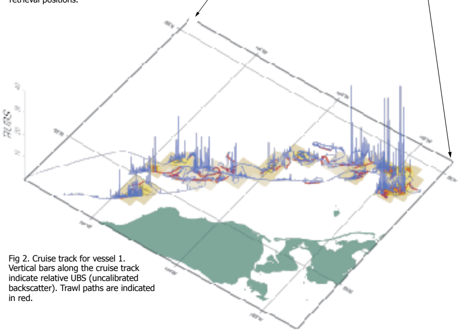

Fig 2. Cruise track for vessel 1. Vertical bars along the cruise track indicate relative UBS (uncalibrated backscatter). Trawl paths are indicated in red.

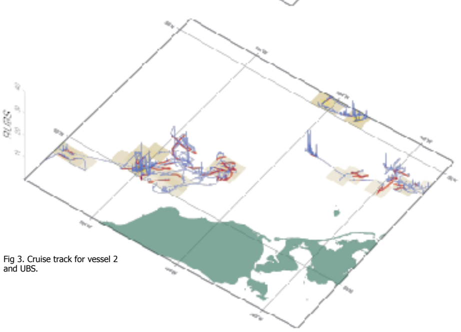

Fig 3. Cruise track for vessel 2 and UBS.

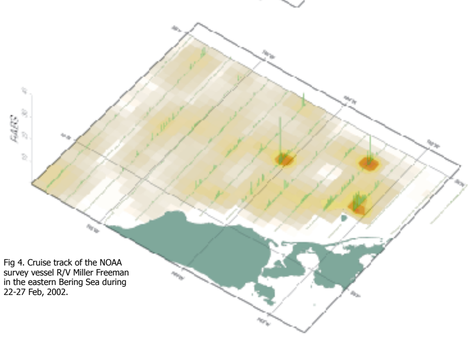

Fig 4. Cruise track of the NOAA survey vessel R/V Miller Freeman in the eastern Bering Sea during 22-27 Feb, 2002.

Discussion

The ability to collect opportunistic acoustic data on fishing vessels is a recent development. There are several directions that development of this data source could take. One path is to make these data more directly comparable to backscatter data generated by scientific acoustic surveys. For example, commercial echosounders can be calibrated using standard suspended-sphere techniques and the vessels could run systematic track lines. Since these activities would require a commitment of ship time, incentives would be needed to induce fishing vessels to participate, such as formal vessel charters or "fish for research" programs. We believe that applying current standards for scientific surveys to acoustic data collected on fishing vessels would be misguided, and may have the effect of stifling research before the utility of these data can be properly evaluated. With the precision and technical sophistication of current acoustic surveys, it is easy to forget what acoustic surveys were like in the 1960s and 1970s when methods were first being developed. Nevertheless, the difficulty of controlling vessel noise on commercial boats, and the complexity of fish response of vessel noise are obstacles not easily surmounted.

Another path of development, and one that we believe may be more fruitful, is to consider opportunistically collected acoustic data as comparable to fishery CPUE data, with similar advantages and shortcomings (Table 1). There are well established methods for standardizing fishery CPUE data through the use of generalized linear models. These methods would be useful for standardizing acoustic backscatter data collected on different fishing vessels, with an ultimate goal of generating indices of abundance. A logical starting point might be that UBS is proportional to s_A, with the proportionality constant being a value unique to each vessel/echo sounder.

Echo-integration software is designed for painstaking analysis of a relatively small number of survey transects. As acoustic data become available from other sources, maintaining the same level of painstaking analysis will be difficult. Robust and relatively automated data analysis techniques are needed to extract the useful information from raw backscatter data for subsequent analysis

Table 1. Comparison of characteristics of survey and fishery data for monitoring changes in abundance/distribution

	Acoustic backscatter data		CPUE data (trawl catch per unit of effort)	
	Data collected with a calibrated scientific echosounder	Uncalibrated backscatter (UBS) from fishing vessels	Scientific trawl surveys	Fishery CPUE data
Density of observations	High	Very High	Low	High
Spatial pattern of coverage	Usually systematic	Non-random, but including both fished and unfished locations	Random or sustematic	Non-random, limited to fishing locations
Temporal coverage	Low—usually limited to annual surveys	High—but only during fishing seasons	Low—usually limited to annual surveys	High—but only suring fishing seasons
Absolute biomass estimate?	Perhaps—subject to certain assumptions	Not at present	Perhaps—subject to certain assumptions	No
Relative abundance index?	Yes	Questionable—not yet adepuately evaluated	Yes	Unlikely-subject of historical debate

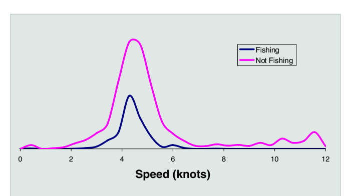

Fig 5. Frequency distribution of vessel speed for a factory trawler in the eastern Bering Sea in winter 2002.

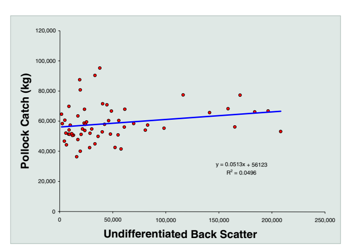

Fig 6. Relationship between summed UBS (uncalibrated backscatter) while trawling and the pollock catch per tow for a factory trawler.